Project information

Keywords

Biology, ecophysiology, agronomy, technology, remote sensing, Geographic Information Systems, statistical modelling

Project title

1.1 Use of remote sensing for increased precision in forage production (“REMOTE SENSING”)

Year

2016

Project leader

Marit Jørgensen, Nibio Holt, Tromsø

Geographical localization of the research project in decimal degrees (max 5 per project, ex. 70,662°N and 23,707°E)

The thirty study fields in Tana are located north and south of the village Rustefjelbma, at about 28°12’E and 70°17’-70°26’N. In Tromsø at 18°65’ – 18°90’ E and 69°58’- 69°65’N, in Harstad 16°16’ - 16°37’ E and 68°74’ - 68°79’ N, in Vesterålen 15°27’ - 15°34’ E and 68°64’ - 68°66’ N. As the project is a national, there are also fields in the south, but those are not listed here.

Participants

Dr. Gregory Taff and Dr. Jørgen Mølmann, NIBIO Holt;

Dr. Audun Korsæth, Dr Tor Lunnan, NIBIO Apelsvoll and Løken;

Dr. Stein-Rune Karlsen and Dr. Corine Davids, Norut AS;

Dr. Kari-Anne Bråthen, UiT – Dept of Arctic and Marine Biology;

Francisco Javier Ancin Murguzur (engaged with Fram centre funding through UiT – Dept of Arctic and Marine Biology);

Dr. Yang Shao, Department of Geography of Virginia Tech, Blacksburg, Virginia US

Norsk Landbruksrådgiving (NLR), Advisory Service (several units)

Flagship

Terrestrial

Funding Source

Funding from Fram Centre:	450 000 NOK for 2016
NRC (Matfondet)	1313 000 NOK for 2016
Private and other funding:	266 000 NOK for 2016
In kind funding UiT	10 000 NOK for 2016
In kind funding Norut	50 000 NOK for 2016
In kind funding Aranica	50 000 NOK for 2016
In kind funding NLR	35 000 NOK for 2016

Summary of Results

WP1 and 2: Pre-harvest yield and feed quality prediction for improved management decisions: We measured the spectral signatures of the 3 most important cultivated forage species: timothy (*Phleum pratense*), Meadow fescue (*Festuca pratensis*) and red clover (*Trifolium pratense*) with the handheld spectroradiometer ASD FieldSpec3, right before the first and the second harvest on experimental plots in NIBIO locations in the north (Holt-Tromsø) and in the south (Apelsvoll-Kapp). For each harvest, dry matter yields of these species were determined. Powered partial least square regression analysis (PPLS) was used to model the relationship between the spectral data and the yield data. The analyses revealed smaller differences in the spectral signature of the different grass species at each location, and larger differences between the locations (Holt and Apelsvoll). Red clover showed a different signature than the grasses and must probably be modelled separately. At Apelsvoll, the yields could be modelled with relatively high R^2 values (0.76) regardless of the species.

WP 3: Estimate variation in grassland production at regional levels by satellite remote sensing imagery

a) Developing methods for monitoring the extent and severity of winter damages using satellite data: We have acquired the database for subsidy applications for winter damages in Norway from the Norwegian Agricultural Agency, and satellite images from areas in ‘normal’ years and years when yield anomalies occurred. We used the AR5 national land classification dataset of Norway (created and maintained from field surveys and air photos by NIBIO) to identify grassland fields, and have demarcated areas with and without winter damages in cultivated grassland fields based on aerial photos in 2010 as ground truth. Using Landsat 5 and 7 data, spectral signals for grassland polygons were extracted for early growing season (e.g. April-June) each year and analyzed for intra-annual and inter-annual variability. A number of outlier detection algorithms were examined to detect spectral signals associated with winterkill events/locations. We also examined MODIS time-series data as input for outlier detection representing areas with high levels of winter damages. As we complete these remote sensing winterkill detection algorithms, we expect a high potential as alternative approaches to monitor extent and spatial pattern of winterkill.

b) Estimating productivity of grassland fields with the use of remote sensing from different platforms: We used a Rikola spectrometer and a MAPIR NDVI camera mounted on a rack over experimental plots at Holt and mounted on a drone (UAV) over selected fields in Harstad right before 1st harvest with the purpose of connecting it with data from FieldSpec3 measurements and satellite image measurements (Sentinel-2). The advisory service (NLR) recorded ground-truth biomass right after these measurements. The Fieldspec3 data were obtained using different angles of detection: 60^{o} and nadir. We could not collect detailed data in Vesterålen due to problems with the UAV. The Sentinel-2 and multispectral UAV-based data, in combination with ground truth data on grass yield and results from in situ Fieldspec measurements, are now being processed and will be analysed together with data for the coming year 2017 to develop algorithms to estimate grass yields and map the spatial variability within and between fields.

Regarding the handheld field spectrometer data (hyperspectral data) of grasslands fields, we added the data collected in summer of 2016 with Fram Centre grant to the data we collected in FINEGRASS during 2014 and 2015. All these data included both field spectrometer data and ground truth biomass samples, assessed through cutting, drying, and weighing. Francisco Murguzur, Hans Tømmervik, and Gregory Taff are working together to test multiple statistical methodologies and spectral indices from the spectrometer to model biomass of the grasses with the highest accuracy possible. Analyses begun only after summer 2016 data were prepared, and are therefore still ongoing.

WP 4: Farmers' fields inventory and capacity building:

Grassland yields and feed quality in farmers' fields have been recorded by counting the number of silage bales harvested, and also weighing and sampling a representative sample of them for feed quality. Approximately 120 fields in total were sampled by the Advisory Service (NLR) in Vesterålen, Harstad/Ofoten region, Tana, and in parts of Møre og Romsdal county. Botanical composition will be recorded in spring 2017. The results from 2016 are not ready yet, but the data from some of these fields will used as ground truth for Sentinel-2 satellite data to model productivity of these fields. The results from the inventory will also be used to monitor grassland productivity, and as background for discussions with advisory service and with farmers on trends in grassland productivity, and the results will also be related to ways in which agronomy in north Norway can address climate change.

Highlights:

1) Grass dry matter yields could be modelled with relatively high R^2 values (0.76) with Field Spec3

2) Grass species (timothy and meadow fescue) seem to have similar spectral signatures, but red clover has a different signature

Satellite image monitoring has promising effectiveness for assessing winter damages in grasslands and for productivity on grasslands, though work is ongoing.

For the Management

Forage is a key resource for ruminant meat and milk production. Information on yields and forage quality on the standing crop could help farmers make appropriate management decisions concerning i.e.: harvesting sequence of different fields according to yield and feed quality, sorting according to feed quality, purchasing the appropriate supplements, stocking rate etc. More precise information on variations at field and regional level can give better knowledge on the links between yields and agricultural practices, soil and climate.

Results on satellite image-assessed extents of grass winterkill can be particularly useful for statistical offices in the future because Norway has now ceased to offer subsidies for winter-damaged lands, and therefore data on winterkill has ceased to be collected.

Published Results/Planned Publications

Shao Y, Taff G, Jørgensen M. "Detection of winterkill in grasslands in Norway using spatial-temporal satellite data mining". Abstract for the annual meeting of the American Association of Geographers, April 2017, Boston, MA, USA.

Planned publications :

Tentative titles scientific publications of the whole project:

Paper 1: Predictions of grass yields by means of radiometric measurements in the VIS-NIR-range and powered partial least regressions

Paper 2: Effects of grass species and phenology on proximal sensing of feed quality parameters using multi-spectral radiometry

Paper 3: Detecting regional extent of winter damage on small grassland fields using satellite remote sensing

Paper 4: Modelling productivity of Norwegian grasslands with Sentinel-2, unmanned aerial vehicles and handheld FieldSpec3 data

Paper 5: Causes and ranges of yield variation in grassland fields in Norway

Communicated Results

Bakken A. K. 2016. «Grovfôr og teknologi». Foredrag ved Strategiseminar - Grovfôr og ny teknologi. Landbruk 21 Trøndelag. 26. januar 2016

Korsæth A. «Vision for HIS and spectroscopy sensors». Presentasjon på dialogmøte med IMEC, Leuven, Belgia 17.03.2016.

Korsæth A. «Ny teknologi i landbruket – gevinst både for bonde og industri». Foredrag på Landbrukskonferansen i Rogaland, Hotel Clarion Energy, Stavanger

Korsæth A.2016. «High-tech-jordbruket kommer for fullt». Foredrag på Sparebank 1 sin fagdag for landbruk, Hamar 02.03.2016.

Korsæth A. 2016 «Landbruksteknologi og systemanalyse». Foredrag og demonstrasjon av teknologi (sensorer, UAVer, robot) for mat- og landbruksminister Jon Georg Dale, Apelsvoll 02.02.2016.

Korsæth A. 2016 «Presisjonsjordbruk - muligheter i grovfôrproduksjonen». Foredrag på Kvithamardagen, Kvithamar 28.01.2016

Jørgensen M 2016. «Bruk av fjernanalyse for økt presisjon i grovfôrproduksjonen". Foredrag på Rådgiversamling 25. August 2016, Holt, Tromsø

Shao Y, Taff G, Jørgensen M. "Detection of winterkill in grasslands in Norway using spatial-temporal satellite data mining". Presentation (submitted) to be given at the annual meeting of the American Association of Geographers, April 2017, Boston, MA, USA.

Interdisciplinary Cooperation

This project is a close collaboration between scientists focused on agronomy (Jørgensen, Lunnan – studying grassland cultivation and effects of agronomy and climate changes on grassland productivity), plant biology (Mølmann – field methods and yield/feed quality analyses), statistical modelling and geographic information science/remote sensing (Taff, Korsæth, Shao, Murguzur, Karlsen and Davids – GIS, modelling and remote sensing of vegetation). We also collaborate with the Agricultural Advisory Service. This brings in different perspectives and competences/knowledge and ensures better and more appropriate choices of methodology from the different fields, etc. It also brings in new ideas. Collaboration with the advisory service who are very close to the end-users ensures that the scientific focus is important and "realistic" for end-users.

On the other hand, coming from quite different scientific fields requires some extra time for learning each other's fields.

Budget in accordance to results

With the Fram Centre funding we could engage Francisco Javier Ancin Murguzur through UiT to do Fieldspec measurements in Harstad region, and it allowed for detailed ground truth as we could pay the Advisory service to do this. The funding has been essential for accomplishing the processing and analysis of Sentinel-2 data and Rikola data for Norut, and will also cover some of the in-kind funding from Norut, as well as in-kind funding for the advisory service. In addition, the funding covered more time costs for Yang Shao at Virginia Technical University.

Could results from the project be subject for any commercial utilization

No

Conclusions

a. To use satellite imagery to assess extent of winter damaged lands, incorporation of a temporal component into analyses has proven key, since winter damaged lands are sometimes resown in the same year, therefore requiring satellite imagery from post-green-up and pre-resowing time points. Such algorithms are currently being tested in the project.

Initial results have shown that UAV-based multispectral mapping is able to detect and map spatial variations in the yield and productivity in agricultural fields. However, these initial results have also highlighted the need for further research into the understanding and characterization of the bidirectional reflectance distribution functions (BRDF), which is a function of both the illumination angle (sun angle) and view angle, and the development of correction methods for its effect on the measured reflectance. Results from this project can be used for future research into the development of simple systems (handhold or small UAVs) that can be handled directly by farmers or foresters.

b. The project has helped to further develop a processing chain for the UAV-based multispectral Rikola camera, including initial corrections for the variability of light intensity and viewing angles. This is important to increase the usefulness of UAVs for vegetation monitoring and the ability to extract vegetation parameters and compare directly with satellite data.